

# Release of *Escherichia coli* from Feathered and Featherless Broiler Carcasses in Warm Water<sup>1</sup>

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**ABSTRACT** Release of bacteria from individual broiler carcasses in warm water was measured as a model of bacterial contamination of scald water. Immediately after shackling and electrocution, feathered and genetically featherless broiler carcasses (n = 24 of each) were immersed individually in 42°C, air-agitated tap water for 150 s. Although any visible fecal material expelled as a result of electrocution was removed before sampling, carcass condition was typical for market-age broilers subjected to 12 h of feed withdrawal. Duplicate water samples were taken at 10, 30, 70, 110, and 150 s, and *Escherichia coli* counts were determined. Samples of initial tap water and contaminated water approximately 2 min after removal of carcasses indicated that *E. coli* could not be detected in the original water source and that mortality

of *E. coli* in the warm water was negligible. Mean numbers of *E. coli* released were 6.2 and 5.5 log<sub>10</sub> (cfu/carcass) at 150 s for feathered and featherless carcasses, respectively. For both feathered and featherless carcasses, the rate of release of *E. coli* was highest in the first 10 s, and the rate declined steadily during the remaining sampling period. This result is compatible with published reports of sampling of operating multiple-tank scalders, indicating that a high proportion of total bacteria in a multiple-tank scald are in the first scald tank that carcasses enter. Higher numbers of *E. coli* released from feathered carcasses are probably due to the much greater surface area of contaminated feathers compared with the skin of featherless carcasses.

**Key words:** scalding, *Escherichia coli*, water, suspended bacteria, feather

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## INTRODUCTION

Hot water scalding is a key step in typical slaughter and processing of broiler chickens. Subjecting the carcasses to a hot water bath makes the feathers easier to remove from the carcasses, but an unavoidable side effect of scalding is that bacteria, fecal material, and extraneous matter are also removed from carcasses and become suspended in the scald water. Many bacteria die in the hot scald water, but some bacteria may move among carcasses passing through the common bath. Movement of pathogenic bacteria among carcasses is a potential concern for public health.

Influences on the numbers of bacteria suspended in scald water include rate of entry of bacteria into water via carcasses, the rate of death of bacteria as influenced by water temperature and pH, and characteristics of scald tank operation, such as tank design, volume, rate of overflow, and mixing characteristics (Humphrey et al., 1981, 1984; Veerkamp, 1989).

Although there are reports of concentrations of bacteria in the water in operating multiple-tank scalders (Veerkamp and Heemskerk, 1992; Cason et al., 2000), a literature search found no papers on the pattern of release of bacteria from carcasses during scalding. The objective of this experiment was to determine the pattern of release of *Escherichia coli* from feathered and featherless carcasses suspended in warm water. Such information might be potentially useful for modeling the death of bacteria during scalding, designing more hygienic scalding systems, and reducing the likelihood of cross-contamination by pathogens.

## MATERIALS AND METHODS

The genetically featherless and feathered broiler siblings used in this experiment were described by Buhr et al. (2003). Twenty-four broiler chickens of each feather type (6 to 10 wk old on the day of sampling) were used in this study, with 2 to 4 chickens of each type sampled on 7 different days over a period of 5 mo. Chickens of both feather types were reared on pine shavings in a single experimental pen. Feed and water withdrawal started approximately 12 h before processing, when feathered and featherless chickens to be sampled were caught and placed in a single plastic coop. Feathered and featherless birds were alternated during the experi-

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ment to equalize the amount of time spent in the coop. After chickens were electrocuted and shackled, any defecations that occurred as a result of electrocution were removed with a paper towel, but otherwise, carcasses were left as they were when removed from the coop.

Carcasses were immersed individually in 26 L of 42°C tap water in a container lined with a plastic trash bag. The temperature was chosen to be warm, but not hot enough to kill *E. coli*. Air agitation was provided by delivering compressed air through perforated copper tubing in the bottom of the container. Duplicate water samples were taken at 10, 30, 70, 110, and 150 s after individual carcasses were placed in the water. The plastic bags were replaced after each carcass was sampled, the container was refilled with clean tap water, and shackles and copper tubing were sprayed with 70% ethanol and flamed.

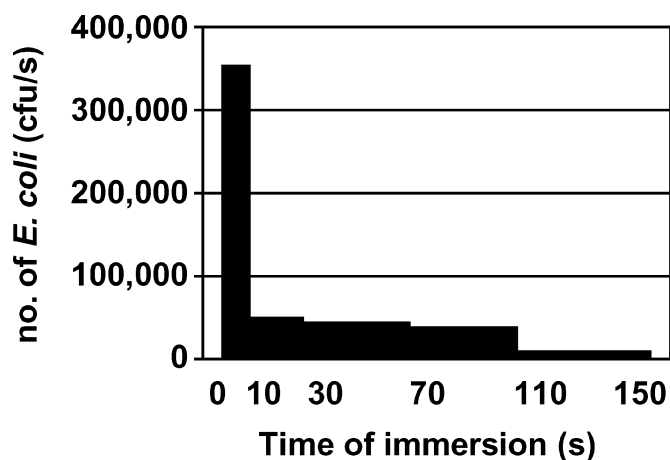
*Escherichia coli* bacteria in water samples were enumerated by plating 1 mL from a serial dilution of the samples on duplicate Petrifilm *E. coli*/coliform count plates (3M Microbiology Products, St. Paul, MN). Plates were then incubated at 35°C for 18 to 24 h, and colony-type characteristic of *E. coli* were counted. Duplicate samples were averaged for each carcass.

Numbers of *E. coli* in the water after 150 s were converted to log<sub>10</sub> and analyzed by ANOVA using the SAS statistical program (SAS Institute, 2000) to compare total numbers of bacteria released from the feathered and featherless carcasses. Numbers of bacteria added to the water in each successive period of time were obtained by subtraction to determine the rate at which bacteria were rinsed off of carcasses.

## RESULTS AND DISCUSSION

Samples from the original water source and from contaminated water samples taken approximately 2 min after removal of carcasses indicated that *E. coli* could not be detected in the original water source and that mortality of *E. coli* was negligible in the 42°C water. *Escherichia coli* was recovered from all carcasses that were sampled.

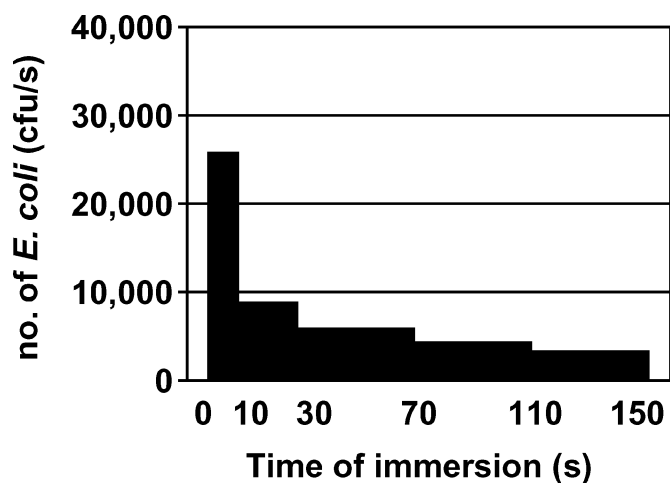
After 150 s in the warm water, the mean number of *E. coli* recovered from feathered carcasses was 6.2 log<sub>10</sub> of cfu/carcass, significantly more (0.7 log,  $P = 0.01$ ) than that recovered from the featherless carcasses. Lower total numbers of *E. coli* were recovered in the present study than reported in other studies that used somewhat different methods to sample feathered carcasses before scalding (Kotula and Pandya, 1995; Buhr et al., 2000). Recovery of higher numbers of *E. coli* from feathered than from featherless carcasses was probably due to the much greater surface area of feathers compared with the skin of featherless carcasses. On a sample weight basis, feathers from various areas of the carcass of broiler chickens before scalding have been reported to carry 1.8 log more *Enterobacteriaceae* (Geornaras et al., 1997) and 0.6 to 1.5 log more *E. coli* (Kotula and Pandya, 1995) than skin samples taken from the corresponding area.



**Figure 1.** Numbers of *Escherichia coli* (cfu/s) released from feathered broiler carcasses rinsed in warm water (42°C) when sampled after 10, 30, 70, 110, and 150 s of immersion. The area under each section of the figure is equivalent to the number of bacteria added to the total suspended in the water during each period of sampling.  $n = 24$  for each period.

There was a high degree of variability in the numbers of *E. coli* recovered from individual carcasses, with SD of 0.94 and 0.81 for feathered and featherless carcasses, respectively. Carcasses with the highest numbers of *E. coli* had more than 100 times the numbers found on the least contaminated carcasses. High carcass-to-carcass variation has been reported for aerobic bacteria on pre-chill carcasses (McNab et al., 1993; Renwick et al., 1993) and for aerobic bacteria, coliforms, *E. coli*, and *Campylobacter* in rinses of prechill carcasses (Cason and Berrang, 2002). High carcass-to-carcass variation in the numbers of associated bacteria appears to be the rule on arrival at the processing plant and throughout processing.

The rate of release of *E. coli* from feathered and featherless carcasses is shown in Figures 1 and 2, respectively.



**Figure 2.** Numbers of *Escherichia coli* (cfu/s) released from genetically featherless broiler carcasses rinsed in warm water (42°C) when sampled after 10, 30, 70, 110, and 150 s of immersion. The area under each section of the figure is equivalent to the number of bacteria added to the total suspended in the water during each period of sampling.  $n = 24$  for each period.

The graphs are similar in appearance but have a different scale on the y-axis. In both figures, the entry of bacteria into the water is graphed in colony-forming units per second against the time among successive samples, so the area under the graph is equivalent to the total number of bacteria released from carcasses into the water during the sampling period. For both feathered and featherless carcasses, the rate of release of *E. coli* was highest in the first 10 s, and the rate declined steadily during the remaining sampling periods. This result is compatible with published reports of sampling of operating industrial multiple-tank scalders, indicating that a high proportion of total bacteria are in the first scald tank (Veerkamp and Heemskerk, 1992; Cason et al., 2000). In a study of a 3-tank scald in a pilot plant, contamination levels in industrial scald tanks were modeled successfully when natural contamination from test carcasses was supplemented with bacteria in additional fecal material that was added to the first tank only (Veerkamp et al., 1991). At commercial scald water temperatures (generally 50 to 60°C), however, numbers of bacteria recovered from each scald tank are influenced by mortality of bacteria and by the counterflow design in the scalders. The present experiment removed the influence of bacterial mortality and water flow among scalders, although rinsing carcasses in water at a lower temperature might have reduced the rate at which bacteria were removed from the carcasses.

Sequential release of bacteria in multiple rinses of the same carcass has been studied. Numbers of bacteria in carcass rinsing data show a pattern of a slightly declining rate of release in successive rinses of defeathered carcasses in terms of aerobic bacteria (Lillard, 1988; McNab et al., 1993), coliforms (Mead and Thomas, 1973), *Enterobacteriaceae* (Lillard, 1988), and salmonellae (Lillard, 1989; Izat et al., 1991). None of these studies reported a significant difference in numbers of bacteria recovered in any 2 consecutive rinses.

The studies mentioned above restarted each successive rinse with no bacteria present in the rinse liquid, unlike a continuous rinse with intermediate sampling of the water, as in the present experiment. The pattern of decreasing numbers of bacteria removed from carcasses in successive samplings may indicate that bacteria already present in the surrounding liquid inhibit further release of bacteria from the carcasses. As the number of suspended bacteria in the rinse liquid increases, it might be expected that the exchange of bacteria between carcass and liquid might approach an equilibrium situation in which some suspended bacteria leave the rinse and are reassociated with the carcass and feathers, thus reducing the net rate at which bacteria leave the carcass and become suspended in the rinse liquid.

It is clear from this study and from sampling in operating processing plants that a large proportion of carcass bacteria leaves carcasses early in scalding. In multiple-tank scalders, use of a relatively short first tank might reduce the numbers of bacteria in later sections of the scald, improving the aesthetic aspects of scald-

ing and possibly reducing the opportunity for cross-contamination of bacteria among carcasses. The higher bacterial loads in industrial scalders are difficult to simulate in a laboratory setting, so a modified scald design would need to be tested in an operating plant.

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